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ABSTRACT

A selective review of literature on the effects of nutrition and malnutrition on educational achievement is presented. Interpretive critiques of studies focus on three areas: (1) the effects of early undernutrition and subsequent intellectual function and school progress; (2) the relationship between the nutritional status of the student and school progress; and (3) the educational consequences of nutrition intervention programs and school feeding. Inferences are made regarding the significance of nutrition as a determinant of school progress and achievement, and implications for nutrition and educational policies are also made based on the data reviewed. It is proposed that nutrition, in particular, and health in general, need to be considered as key determinants of school progress and achievement, and that they are amenable to changes through relevant social and educational policies. Appended are summary tables of the studies reviewed. (JD)

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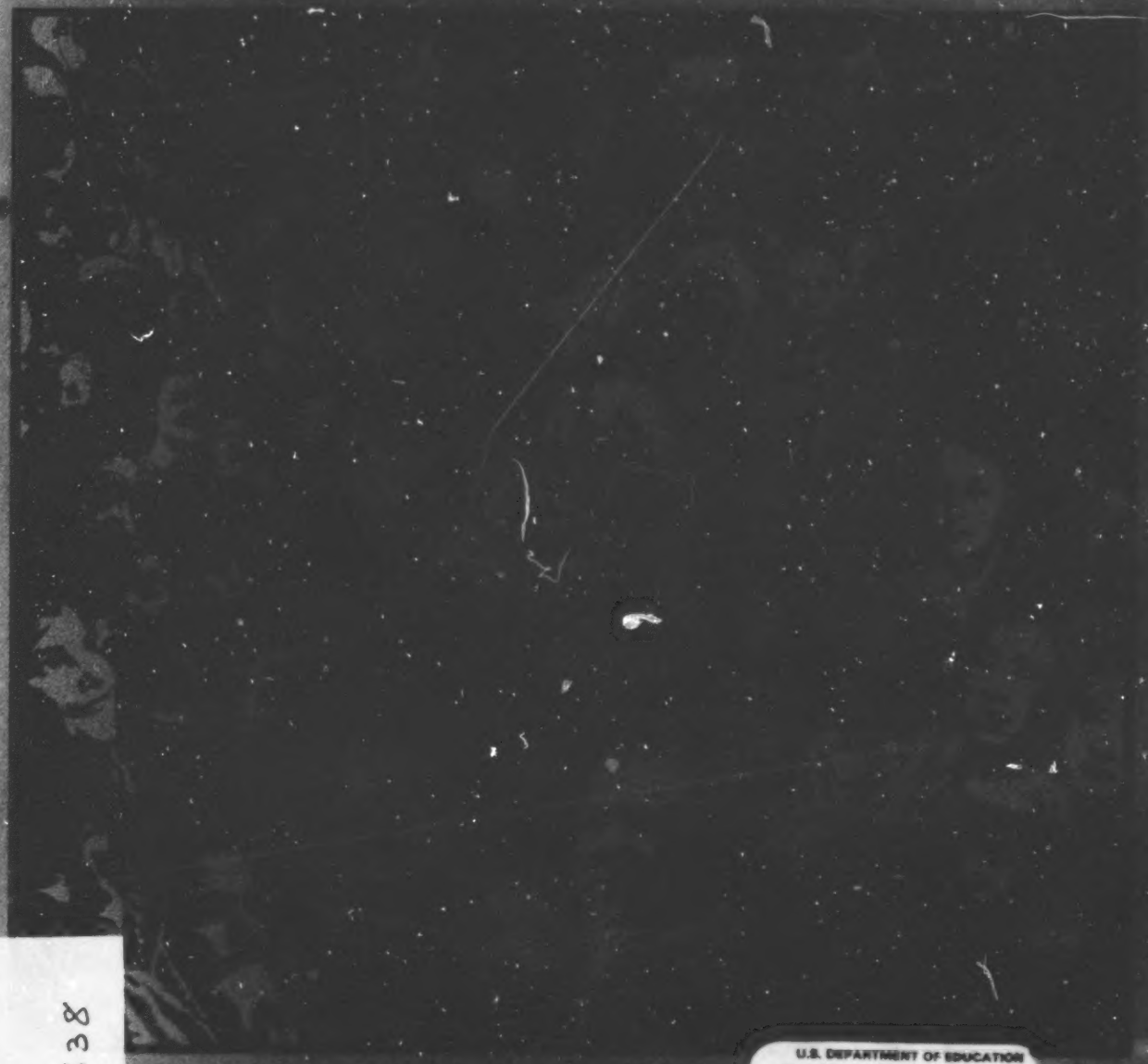
Nutrition and educational achievement

by Sinasia Pollitt



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NUTRITION EDUCATION SERIES

ISSUE 9

NUTRITION AND EDUCATIONAL ACHIEVEMENT

by

Ernesto Pollitt, Ph.D.

Nutrition Education Programme
Division of Science, Technical
and Vocational Education

United Nations Educational,
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PREFACE

The scientific evidence presented in this monograph shows that malnutrition in infants and children is a risk factor in the formal educational system. The conclusions advanced indicate that it is important to include nutrition as a determinant of school performance and achievement. Early malnutrition or poor nutritional status among school children has significant adverse effects on school progress. There is a direct relationship between the prevalence of malnutrition in a country and the contribution by malnourished children to educational wastage. Children who are undernourished and whose learning is slow have difficulties mastering school material and are among those with high chances of repeating grades and dropping out early from school.

Dr Pollitt, a Peruvian, is a world-renowned nutrition and child development specialist. Currently Professor of Nutrition and Convener of the Behavioral Sciences Program at the School of Public Health, The University of Texas Health Science Center at Houston, Dr Pollitt has himself conducted many of the important scientific studies in the area of nutrition, child development and educational performance.

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The ideas and opinions expressed in this monograph are those of the author and do not necessarily represent the views of Unesco. The designations employed and the presentation of materials throughout the monograph do not imply the expression of any opinion whatsoever on the part of Unesco concerning the legal status of any country, territory, city or area of its authority or concerning its frontiers and boundaries.

INTRODUCTION

This monograph presents a substantive but selective review of the literature on the effects of nutrition and malnutrition on educational achievement. It provides an interpretive critique of the studies reviewed and focuses on three areas:

(1) the effects of early undernutrition and subsequent intellectual function and school progress;

(2) the relationship between the nutritional status of the student and school progress; and

(3) the educational consequences of nutrition intervention programmes, such as school feeding.

Serious methodological shortcomings in many studies in this area of nutrition and education cloud the significance of findings. However, when data is pooled and analysed together certain conclusions are justified.

Inferences are therefore made regarding the significance of nutrition as determinant of school progress and achievement. Some implications for nutrition and educational policies are also made based on the data reviewed. A basic proposition of this monograph is that nutrition, in particular, and health, in general, need to be considered as key determinants of school progress and achievement, and that they are amenable to changes through relevant social and educational policies.

Further details on the studies discussed can be found in the summary tables of the Appendix. Readers interested in obtaining an edited set of the papers mentioned can write directly to the Unesco Nutrition Education Programme.

I. DETERMINANTS OF SCHOOLING

Schooling as a formal educational system is one of the most potent socializing agents to which many individuals are exposed. It has beneficial effects on psychosocial development and on the acquisition and utilization of knowledge, contributing to the economic and social development of individuals and society, both in developed and developing countries. Significant positive associations have been reported between education, personal income, and occupational level (Beirn, et. al. 1972; Simmons and Alexander, 1975). Per capita growth from the gross national product of a country and the per cent of the population of school age enrolled in the secondary level of education have also been statistically associated (Razin, 1977). In fact, the general direction of the available information, despite a few controversial findings, support the conclusion that schooling is an instrument of individual and social change, increasing the probabilities of general well-being.

There is a substantive body of literature on determinants of school enrollment, attendance and achievement. Within this literature heavy emphasis has been given to social and economic factors in the family, and to the quality of schooling. In general, these can be classified into endogenous and exogenous determinants to the child and the family.

Nutrition is an endogenous factor that affects learning ability and skills before and after the child is in school. However, both within the nutritional and educational literature, nutrition has received little attention as a determinant of school progress. Yet, as this monograph will show, there is data that clearly shows that malnutrition in infants and children is a potent contributor to school wastage. Before discussing the specific issue of nutrition as a determinant of school progress a general discussion on school determinants is presented.

Endogenous factors

What a child can do both physically and intellectually, as a result of native endowment and developmental history are endogenous factors generally classified as aptitudes. Learning ability for example reflects in part the child's scholastic aptitude. Likewise, social-emotional characteristics reflected in the child's independence, achievement motivation, self reliance, impulse control, and stability, among other personality characteristics are endogenous factors classified as attitudes. Aptitude and attitudes, however, are not only input or determinants of schooling, but outcomes as well. In this regard, learning how to learn is one of the most direct ways in which schooling shapes the aptitudes of children.

The education of the parents, the income of the family, the child's caretaking arrangement, his health and dietary intake, are also endogenous factors that determine in part the child's schooling and performance. Direct effects are dramatic whenever the financial situation of the family, or the child's poor health, impedes him continuing schooling. The family's rearing and socialization practices which shape the child's aptitudes and attitudes regarding school progress and achievement illustrate indirect effects.

Generally there are close and causal relationships among endogenous factors. For instance, in some societies the family's structure (i.e. size) determine the caretaking arrangements, which in turn will influence the child's time in the school, or even the child's educational achievement. In some countries in Africa and Latin America economic investments in the education of children within a family are related to birth order. Parents in low income segments of different populations have been reported to make larger financial investments in the education of the older siblings, with the expectation of establishing a sibling educational chain (Okeijidi et al.

1976; Birdsall, 1980). Similarly, the size of the family, the education of the parents, and the nature of the verbal communication within the household, determine opportunities for learning, and the development of achievement orientation (Deere, et al. 1982). Aptitudes and attitudes are therefore shaped, and the history of the child in school is partly set by the family's history and the learning environment it provides.

Exogenous factors

The quality of schooling, the training of the teachers, the availability of books and other educational materials exemplify exogenous factors that influence the quality of the formal educational process. They determine to a large extent the nature of the final outcome: that is, the abilities and attitudes that a student will possess in order to cope with the demands of the social system. Decisions about these key exogenous factors, however, generally fall outside the family's influence, particularly among low income segments of the population in developing countries. Budgetary allocations of regional or central governments to the educational sector determine the quality of schooling and set limits to a student's academic progress. These allocations define the social and educational policies of governments and represents their commitment to the formation of human resources and human capital. One element which contributes to determine how such allocations meet the eduational needs is the availability of information on the determinants of schooling, and how schooling shapes the abilities and skills required by the social system.

Endogenous and exogenous factors are not independent of each other. In many developing and even developed countries children exposed to family conditions conducive to scholastic achievement are enrolled in schools that promote the acquisition of cognitive and social skills and abilities which are needed by, and rewarded economically in society. At the other side of the social spectrum, children of parents who are either illiterate or have not completed primary schooling often go to schools where pupils from two or more grades share the same room and the same teacher. Books are generally not available, and the teachers have had limited pedagogical training. These educational experiences lower the probabilities of economic success of children in developing countries, particularly among those societies undergoing fast social and economic change.

A distinction between endogenous and exogenous factors that shape aptitude and attitude before and after the child is enrolled in formal education is analytically useful. The pre-school child develops a repertoire of behaviours and psychological traits that determine in part the initial response to schooling and subsequent academic progress. These traits result from native ability and early developmental history. For example, exposure to so-called infant or pre-school stimulation programmes contributes to the child's performance in primary and even secondary schooling (Consortium for Longitudinal Studies, 1983; International Development Research Centre, 1983). Likewise, maternal caretaking behaviours, such as frequency and quality of verbal communication, effect the pre-school child's language skills, which in turn influence school performance.

The effects of both endogenous and exogenous factors are also observed after the child is enrolled in school. There is, for example, substantive evidence showing how the characteristics of the family, or the educational level of the parents, will affect the child's school progress. As already noted, these effects are direct, such as when they determine the child's early departure from the school system, or indirect, like in those cases where they shape the child's pursuit of academic achievements (Irwin, et al. 1978).

Aptitudes and attitudes are susceptible to major changes during educational process. There are complex interactions among exogenous and endogenous factors that affect the child's development during the pre-school and school age period. Pre-school children with good intellectual endowment and exposed to family environments conducive to learning may be handicapped if their schooling is poor. Conversely, an effective school system may compensate for family deficiencies. By the same token, there will be an adverse synergistic interaction in those cases where the initial developmental experiences of the child are poor and the school system is ineffective.

In summary, formal education represents a long and complex process which is multifactorially determined. Enrolment, attendance and achievement are determined by a series of factors that fall within as well as outside the child and the family system. The influence of these factors, from infancy through the school-age period, facilitiate or hinder the development of native abilities and skills. Moreover, factors that influence the educational process in the same direction tend to be associated to each other. Thus, poverty in the family will be coupled with poor schools which rarely provide the learning experiences conducive to the acquisition of those mental abilities and learning skills necessary within society.

Nutrition as a determinant of schooling

In comparison to studies on the social and economic determinants of schooling, there is a scarcity of information on the effects that nutrition and health have on school enrolment and academic progress. Conceivably, this lack of information has contributed to the little attention given by educational policies in most countries in the world to the nutritional and health status of the students.

In developed countries there generally is a low prevalence of undernutrition, of specific nutritional deficiencies, and of disease conditions which place at risk the school progress of children and are major causes of public health concern. In developing countries - particularly among the low income segments of populations - infections and malnutrition are often endemic. Among them the prevalence of protein-energy malnutrition (PEM), and micronutrient deficiencies (including vitamins and minerals), is generally extremely high (Pellet, 1983). Gastrointestinal and upper respiratory infections have high frequency of occurence, increasing the risk of malnutrition and mortality (Ashworth, 1982; Chen & Scrimshaw, 1983). Accordingly, in these countries malnutrition, as a risk factor for the educational future of infants and children, should be a major concern for health, nutrition and educational policies.

The high prevalence of malnutrition among infants and young children has serious developmental implications, because these age periods are critical in the growth and development of children. Basic aptitudes and attitudes are shaped in infancy and early childhood; moreover, during these developmental periods there is a high demand for energy to meet biological and social challenges of growth and maturation. Likewise the socio-economic context of malnutrition becomes particularly relevant when it is seen in the light of what is currently known on environmental determinants of psychobiological development. Children with a history of malnutrition are generally born into families with the lowest income, and with the lowest levels of education as compared to other families within the same community. This environmental context can accentuate the adverse effects of the nutritional deficiencies and vice versa.

As children grow older biological maturation tends to move them - as in all living organisms - towards a normal course of development. In other words, adverse developmental effects from early trauma may be reversible with maturation if the child is exposed to a salutary social environment. However, the environmental

conditions in which malnourished children generally live may preclude this process of reorientation. The socio-economic conditions of the family and the biophysical environment to which these children are exposed is far from salutary. Moreover, these adverse environmental conditions generally do not undergo any significant change as the child grows older. This continuity works against re-routing the development of children with a history of malnutrition towards a normal path.

Nutritional deficiencies

A brief description of protein - energy malnutrition, iron deficiency, vitamin A deficiency, and iodine deficiency follows. Out of these four types of malnutrition the first three are highly prevalent in many developing countries. Iodine deficiency exists throughout many regions in the world , but has a more restricted geographical distribution as compared to protein-energy malnutrition, vitamin A and iron deficiency. These four types of malnutrition can affect the behavioural development and adaptation of children. However the studies reviewed are restricted to protein - energy malnutrition, hunger and iron deficiency. Studies on vitamin A and iodine deficiency have been excluded because of lack of substantive information and the nature of their behavioural effects. Severe vitamin A deficiency results in blindness which may preclude the child from attending regular schooling. Iodine deficiency can result in cretinism which is an extreme form of mental retardation. The concern in this review is more with specific and mild-to-moderate effects on cognitive development that affect the child's educational process.

Protein-energy malnutrition:

The nutritional problem with the highest prevalence in developing countries is protein-energy malnutrition. Infants and pre-school children, pregnant and lactating women are particularly at risk. Protein-energy malnutrition is generally caused by a deficient diet within a severely economically impoverished environment. Most children with protein-energy malnutrition are generally born into, and develop in, an unsanitary environment with few early opportunities for learning and psychosocial stimulation, and are constantly exposed to agents that will lead to infectious diseases.

The most severe forms of protein-energy malnutrition are: marasmus, kwashiorkor, and marasmus-kwashiorkor. The first is the result of a deficient diet both in protein and energy as well as of multiple other deprivations. Severe growth retardation is characteristic of the marasmic child. The etiology of kwashiorkor, on the other hand, is basically due to a deficient protein intake, although it may be precipitated by an infectious episode. Growth retardation is often part of the clinical picture of the kwashiorkor child. Marasmus-kwashiorkor is the most frequent form of severe malnutrition seen and combines the symptoms of the marasmic and kwashiorkor child.

Wasting is another nutritional term currently used to define severe malnutrition among infants. It defines a child whose body weight is significantly behind what it should be for his chronological age and for his height. The following table presents some estimates of wasting reported by UNICEF (1984) on 12 to 23 month-old infants in countries with different infant mortality rates. Among those countries with different infant mortality rates of 100 or more per 1,000 live-births the figures of wasting are impressively high. Out of nineteen countries in twelve of them, 10 per cent or more of their 12 to 23 month-old infants are classified as wasted.

Percentage of Wasting Aged 12-23 Months, 1975 - 1979

GROUP OF COUNTRIES	% OF AGE-GROUP
A. VERY HIGH INFANT MORTALITY COUNTRIES (IMR OVER 100)	
Upper Volta	17
Sierra Leone	26
Yemen Arab Republic	17
Malawi	36[1]
Benin	17
Liberia	8
Nepal	27
Rwanda	26
Senegal	22
Yemen, PDR	36
Bangladesh	53
Burundi	39[2]
Egypt	3
Pakistan	23
Cameroon	5
Haiti	18
Lesotho	11
Togo	9
Zaire	10
Average	21.2
Range	50.0

GROUP OF COUNTRIES	% OF AGE-GROUP
B. HIGH INFANT MORTALITY COUNTRIES (IMR 60-100)	
Burma	44[3]
Ghana	39
Indonesia	26
Papua New Guinea	52
Tunisia	3[2]
Honduras	10[4]
Nicaragua	2[4]
Botswana	13
Brazil	6[2]
El Salvador	6[4]
Kenya	8
Dominican Republic	7
Guatamela	7[4]
Jordan	9
Colombia	2[5]
Average	15.6
Range	50.0
C. MIDDLE INFANT MORTALITY COUNTRIES (IMR 26-50)	
Philippines	16
Thailand	18
Sri Lanka	22
Yugoslavia	1[1]
Panama	9[4]
Costa Rica	3[4]
Austria*	1
Average	10.0
Range	21.0

1. 1969
2. 1974
3. 1970
4. 1967
5. 1980

* Low Infant Mortality Country (IMR 25 and less)

Mean (Total Countries) = 17.2
Range (Total Countries) = 53 - 1 = 52.

Source: Unicef 1984

Based on what is known on the socio-economic context of malnutrition, it is to be expected that the majority of these children labelled as wasted are living under conditions of extreme social and economic deprivations. Thus as proposed in this monograph, it is to be expected that a large proportion of these children in these countries will have serious difficulty in adjusting to formal educational demands.

Iron deficiency anemia:

This is probably the micronutrient deficiency with the highest prevalence in both developed and developing countries. Moreover, in many parts of the world it generally coexists with protein-energy malnutrition or with other micronutrient (vitamin and minerals) deficits. It is now estimated that there are about 1.3 billion people with iron deficiency anemia around the world. The functional consequences of iron deficiency anemia have not yet been fully established. However, there is conclusive evidence that it has a debilitating effect on worker's productivity, and, as evidenced in this monograph, on the attention and learning of children.

Iron deficiency anemia is an extreme form of this micronutrient deficiency; however, there may be depletion in the storage or in the transport of iron before the oxygen carrying capacity of blood is affected. Iron deficiency is generally caused by a deficient intake or absorption of iron. Anemia may also be caused by folate deficiency, particularly among pregnant women and children.

Vitamin A deficiency and xerophthalmia:

Vitamin A deficiency is prevalent among populations where children are weaned to a diet that includes small amounts of animal foods, green leafy vegetables and fruits. It causes significant reduction in the capacity of the organism to resist infection, disorders in metabolism, and eye lesions in the cornea that progressively worsen until blindness occurs. Vitamin A deficiency generally exists in conjunction with protein and energy deficiency, which in turn accentuates the effects of the vitamin deficiency.

Xerophthalmia - also called 'disease of darkness' - is frequently found in children younger than five years old, and results from lesions to the cornea. As the condition becomes worse the child becomes blind and the lesion is irreversible. Of the survivors of severe xerophthalmia it is estimated that 25 per cent are totally blind, and 15 to 25 per cent have unimpaired sight. The World Health Organization has estimated that there are about one million children in the world who have suffered from some degree of visual impairment due to vitamin A deficiency. It is not known, however, how many children are not able to go to school, or do not function well in school because of visual disorders secondary to vitamin deficiency.

Iodine deficiency and goitre:

Severe iodine deficiency results in hypothyriodism, a pathological state characterized by an impairment in synthesizing thyroid hormone. Unless the thyroid gland is non-functional or absent, the impairment is accompanied by goitre, or thyroid gland enlargement, which results from hyperstimulation of the thyroid gland. Severe endemic goitre - which is generally the result of a diet deficient in iodine - has been clearly associated with endemic cretinism in different world regions (Clements, 1976). A cretin is characterized by severe intellectual retardation, dysarthria and possibly deafness. With few, if any exceptions, cretins are not able to attend school because of their severe intellectual limitations. They represent the most dramatic example of the way a nutritional deficiency may stop a child from taking advantage of the formal educational system.

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II. EFFECTS OF MALNUTRITION IN INFANCY AND THE PRE-SCHOOL PERIOD ON SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION

Most studies on the effects of protein and energy malnutrition during the infancy or pre-school period on the performance in intelligence tests or in school achievement measures in childhood and adolescence have been restricted to cases with a history of severe protein-energy malnutrition. As already indicated, severe protein-energy malnutrition includes kwashiorkor (protein deficiency), marasmus (energy and protein deficiency), and marasmus-kwashiorkor, which combines signs and symptoms of both conditions. Moreover, not all the studies report school measures: some are restricted to intelligence or cognitive test scores. Their inclusion in this review is based on the assumption that intelligence test measures are rough indicators of the learning ability of the child. It is recognized, however, that IQ or other measures of cognitive function are not perfectly correlated with academic achievement and can only be taken as an individual's learning potential.

Out of the thirteen studies summarized in Table 1 of the Appendix targeted to measure the effects of severe protein-energy malnutrition in infancy and the pre-school period on school achievement and intellectual function, ten of the studies report that in comparison to well-nourished control children, children with a history of malnutrition scored significantly lower in intelligence test scores and school achievement scores. The magnitude of the deficits however observed in the malnourished children is not uniform across studies. While some report severe cognitive deficits in the undernourished children and large differences in intellectual function between these children and their controls, others report very mild effects from early undernutrition. For example, on the one hand Stoch and Smythe (1976) in their 15 year-old follow-up of children with a history of severe undernutrition in infancy report that they had a 25 IQ point deficit in comparison to their control group. The mean IQ of the boys with a history of undernutrition was as low as 55.7. On the other hand, the IQs and school achievement of children with a history of malnutrition who were placed for adoption in a Korean agency and adopted by families in the United States (Winick, et al. 1979), were lower than that of their controls. However, their IQ and school performance were similar to, or higher than that of the United States standards.

Some important developmental questions in connection with the nature and magnitude of the effects of early protein-energy malnutrition have to do with the time of onset of the malnutrition, the type of malnutrition and its severity.

Four studies (Hoorweg & Stanfield, 1979; Lien, et al., 1977; Nwuga, 1977; Richardson, 1980) assessed the relationship between time of hospitalization (or adoption) and severity of the deficit in intellectual performance. A reason for looking at the time of hospitalization is because it is a crude indicator of the onset of the malnutrition. Three of these studies found that age at hospitalization was independent of the severity of the deficit. The fourth study (Lien, et al. 1977) assessed the impact of time of admission to an adoption agency (before and after 3 years of age) and the performance of the children at a later age on school achievement and intellectual function. This comparative analysis also yielded no statistically significant effects of age at admission on school performance or intelligence testing. However, an analysis of the relationship between time of adoption (before or after 4 years of age) by families from the United States and performance yield statistically significant effects. The mean IQ and school performance of the children adopted before their fourth birthday was higher than that of those adopted at an older age.

The findings from the four studies reviewed in connection with the relationship between time of hospitalization or enrolment in adoption agency and cognitive or

school achievement deficits provide no support for the hypothesis that the timing of the malnutrition may be a critical factor in the magnitude of the deficit observed at a later age. However, this interpretation must be interpreted cautiously. There is no way of assessing accurately the developmental and nutritional history of the cases studied because of the retrospective nature of the studies.

In contrast to the negative findings on the timing of hospitalization the evidence on the effects of the severity of undernutrition (measured by the degree of stunting) indicate that this is a critical developmental variable. The children adopted from a Korean agency after their third birthday, (Lien, et al. 1977), were divided into three groups according to their degree of growth retardation at the time of enrolment in the agency. Later in school there was a positive association between school performance and IQ and their initial growth retardation. The study of the children adopted sometime during their first two years of life had a similar finding (Winick, et al. 1979). Likewise, Hoorweg and co-workers (1979) showed an association between severity of undernutrition (as indicated by varied signs and symptoms) in early life and intellectual performance during school age.

A well-designed study (Grantham-McGregor, 1982) focusing on pre-school children, analysed the relationships between the degree of growth retardation, and other chemical signs associated with severe protein deficiency and the severity of intellectual performance among children recently rehabilitated from severe malnutrition. The strongest predictor of intellectual deficit was the degree of growth retardation.

Conversely, Richardson (1980) failed to find an association between type and severity of malnutrition and degree of cognitive deficit in the school age period. Height and weight measures at admission to the hospital were used to define the degree of undernutrition. These two measures, and a social background measure were then correlated with later IQ. An analysis to measure the effect of each variable on the outcome variable controlling for the effects of the others, showed that the socio-economic background of the children was the only variable that made a significant contribution to IQ.

Although the findings from the studies reviewed above are not fully consistent with each other, most of the evidence supports the hypothesis that the severity of the nutritional deficit is positively associated with the magnitude of the cognitive deficiency during school age.

Two studies conducted in the Caribbean assessed the school behaviour and performance of children with a history of severe malnutrition. One was carried out in the island of Barbados (Galler, et al. 1983) and the other in Jamaica (Richardson, 1980). The Barbados study showed that malnourished children in comparison to control children (matched by age, sex, and handedness) had more significant problems in at least three academic related areas: cognition, social interaction, and emotional stability (particularly the girls). The Jamaica study also showed that in comparison to control children the malnourished children had lower IQ scores and lower academic achievement.

The remaining two studies (Bartel, et al. 1977; Das & Soysa, 1978) reported no detectable effects of the nutritional history. Both studies found that there were no differences in IQ or in other measures of intellectual function between malnourished and control children. The first study compared malnourished (kwashiorkor or marasmic-kwashiorkor) black children with siblings and yardmates close in age who were in good health and the second study compared malnourished children who had been hospitalized for kwashiorkor and marasmus with well-nourished siblings and neighbourhood children. Both studies showed no differences between the malnourished and control children in any of the intelligence tests used that were administered in childhood or early adolescence.

Effects of family environment

Richardson (1980) showed that, as compared to the families of the controls, the families of the malnourished children were more economically disadvantaged. Moreover, the social-familial environment of the children was a better predictor of school achievement than the child's height (which is an indicator of nutritional history). The better the family situation, the higher the chance of intellectual rehabilitation among the malnourished children. Analysis of the interactions between a child's social background and child's height indicated that those worse off were short and lived among the most severely deprived families.

The salutary effects of a family environment on the development of mental abilities and school competence are clearly observed in the two adoption studies (Winick et al. 1979; Lien, et al. 1977). Both included children who were severely malnourished in infancy, later housed by an adoption agency, and subsequently adopted by families who met the children's physiological and psychosocial needs. Accordingly, when the children were at school the sequelai from their early nutritional trauma was minimal, and they could perform in the formal educational system up to the level of the national standards.

Critique of the studies

A critical methodological problem shared by all the studies included in this section is their use of a retrospective research design. The investigations were conducted once the children were already malnourished, or following nutrition rehabilitation. Accordingly, it was practically impossible for the investigators to demonstrate accurately that the malnourished and the control children were developmentally and socially equivalent prior to the onset of malnutrition. The malnourished children may have been developmentally handicapped before they became malnourished; thus, the differences observed between malnourished and control children in their school performance or in measures of cognitive function, may not be due to the differences in their nutritional history. Moreover, as demonstrated by Richardson (1980) there are strong reasons to suspect that the families of malnourished children are often more severely deprived than those from the same communities but with well nourished children.

Conclusions

From a strictly scientific perspective it must be concluded that, because of methodological limitations, the data from the studies reviewed do not provide a basis from which to infer that malnutrition is a causal risk factor for the cognitive development of children. However, it must be recognized that there is an impressive consistency in the nature of the research findings. Clearly, there is a trend in the data that suggests that malnutrition is a developmental risk factor, and that it coexists with an array of other biophysical and social environmental factors that are also hazardous to the psychosocial development of children. Thus, while no study stands alone to demonstrate the long term functional consequences of early malnutrition, the body of data available, placed in the context of, or understanding of, child development, defines malnutrition as a risk factor in the formal educational process.

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III. NUTRITIONAL STATUS, SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION

Are the cognitive or learning abilities of the undernourished or iron deficient anemic child in jeopardy? Does iron deficiency anemia, or hunger, affect attention, concentration or memory in the classroom setting? This section focuses on these questions relevant to millions of children in the developing world, and of critical importance for educational policies.

Four of the studies reviewed relate nutritional status measures such as growth retardation or iron deficiency with school performance and behaviour. A fifth study included in the review focuses on the association between taking or not taking breakfast, and problem-solving at lunch time.

Growth retardation

A study conducted in Singapore (Chun, 1971) assessed the relationship between the physique of students and success in passing the Primary VI examination. 12 year old children were classified according to body size into three groups: tall (90 per cent percentile Hong Kong growth standard), average (10 per cent and 90 per cent percentile growth standard) and small (below 10 per cent percentile). Findings showed a statistically significant association between the number of failures in the examination and the body size group classification. Children in the tall group had a 78 per cent chance of passing the examination; those in the average group a 50 per cent chance and those in the small group had only a 25 per cent chance of passing the examination.

Some methodological problems in this study must be taken into account before drawing conclusions.

The study provides no information on the socio-economic status of the children. This omission is unfortunate because it is well known that rate of physical growth is associated with socio-economic status which also affects the development of learning aptitudes and attitudes. Thus, it is impossible to discriminate between those effects from nutritional status and those from socio-economic background.

The data from this study does not suffice to determine whether the educational effects attributed to nutrition are related to past nutritional history or to present nutritional status. The poor school performance of the small group children could be related to an intellectual deficit associated with an early history of under-nutrition. Alternatively they could also result from deficits in attention and concentration related to current nutritional deficiencies. The limited information reported in the paper precludes a conclusive inference.

Another study (Popkin & Lin-Ybanez, 1982) on general nutritional status and school achievement among 12 - 14 year old children conducted in the Philippines addressed two questions. One dealt with the relationship between (a) body size (weight/height) and (b) hemoglobin measures to detect anemia and performance in an educational achievement measure.

Low hemoglobin values - which is an indication of anemia - was associated with low scores in a language leaning test and in a composite test score. Low hemoglobin values were also related to high absenteeism. Likewise a small body size (weight-for-height measure) - which is interpreted as an indication of protein-energy under-nutrition - was related to poor scores in tests of mathematics and poor concentration. These associations between nutritional status measures and school performance remained after the effects of the socio-economic status of the children were controlled.

A limitation of this study is that it does not provide sufficient detailed information on the body measures characteristics of the students. On the other hand the correlation reported between hemoglobin and school performance is most revealing in the light of the data now available on iron deficiency and cognition.

Iron deficiency anemia

Two studies in the United States of America have assessed the relation of iron deficiency anemia and school performance (Webb & Oski, 1973; 1974). Both were conducted among 12 - 14 year old predominately black students attending a secondary school in an economically deprived urban area. The anemic students had hemoglobin which ranged from 10.1 to 11.4 grams (gm/dl) while that of the controls ranged from 14.0 to 14.9 grams (gm/dl). The outcome measures used were a composite score of the Iowa Tests of Basic Skills, Levels A-F/Form 3, and a behavioural adjustment scale which included items on aspects of personality disturbances, inadequacy-immaturity, and conduct problems.

The composite score in the Iowa Test of the anemic students was significantly lower than that of the control students. Moreover, the lowest level of performance was observed among the older anemic children. The adjustment ratings failed to yield any statistically significant findings. The only finding which suggested a between-group behavioural difference was the rating related to conduct problems. Anemic students tended to have more severe conduct disturbances than non-anemic students, regardless of age.

A critical question in these two studies on predominantly black adolescents is whether or not these students were indeed anemic. Black populations generally have hemoglobin levels which are lower (about 0.5 to 1.0 grams (gm/dl) than that of caucasians. Among well-nourished populations this difference is not related to differences in the intake or absorption of iron, but is likely to be related to genetic differences. Thus, at issue here is how many of the children in the two studies were genuine cases of anemia. Socio-economic differences between groups could well account for the differences in achievement measures reported.

A well-controlled experimental study on the relationship between iron deficiency anemia and school performance was conducted in Semarang, Indonesia (Sumantri & Pollitt, 1984). This study included 9 to 12 year old children from three rural schools. Prior to the first behavioural evaluation, children were treated for parasites to ensure effective absorption of iron supplements. The children were classified as either iron deficient anemic or non-anemic and then tested with an IQ test (Raven Progressive Matrices), a concentration task, and an achievement test which included four subject areas: biology, language, arithmetic, and social studies. The iron deficient anemic children and non-anemic control children were then randomly assigned to either an iron treatment group (receiving iron supplements) or a placebo treatment group (no iron supplements). Three months after treatment, the children took for a second time the achievement school measures and the concentration task. The iron body indicators (hemoglobin and transferrin saturation) of the iron deficient children who had been treated with iron had significantly changed, and were at the same level as that of the non-anemic control children. In the first evaluation, the iron deficient anemic children scored significantly behind the control children in the concentration task and in the school achievement measure. Following the iron treatment intervention there was a statistically significant improvement in the school test performance of the iron deficient anemic children receiving iron supplements. Conversely, the mean scores in all tests of the other three groups were not significantly different between the first and second evaluations. This study provides some of the most clear experimental evidence currently available of the salutary effects of iron treatment on learning of school-age children who are iron deficient.

One issue not addressed in this Indonesian study is the question of which specific cognitive processes, affected by iron deficiency, interfere with learning. Attention, maintenance, selective attention, concentration, perceptual organization, short-term memory, or conceptual learning, are some of the cognitive processes that are likely to be affected, but conclusive evidence in this regard is not yet available.

Hunger

A recently published paper (Pollitt, et al. 1983) focused on short-term fasting and its effects on problem-solving among 9 to 11 year old well-nourished middle-class children. The paper includes the results of two experimental studies that used the similar research protocol and obtained similar findings. The children were brought into a clinical research centre in the late afternoon. A complete medical examination was given and the children were fed dinner. They spent the night at the centre: in the morning they were either fed breakfast or had to fast up to noon-time when they ate lunch. At noon, before a battery of tests was given to measure cognitive tempo, problem-solving ability, incidental learning and short-term memory. A week later the children returned to the centre and followed the same research protocol; however, at this second admission the breakfast treatment was reversed. Those children that ate breakfast in the first session fasted in the second session, and vice versa.

In comparison to the fasting state the children in the breakfast condition made less errors in the problem-solving situation. Moreover, the children in the fasting state paid more attention to the stimuli that were irrelevant to the task at hand; that is, under this condition the children were more likely to use ineffective cognitive strategies in problem-solving.

Conversely, an experimental study (Dickie & Bender, 1982) conducted in the United Kingdom, failed to show any effects of omitting breakfast on different cognitive measures. In a boarding school students were randomly assigned to two groups and were tested in the first week on three consecutive days after their normal breakfast routine. The next week students were again tested on three consecutive mornings but the experimental group omitted breakfast while the control group ate breakfast as usual. Cognitive performance was assessed by two short-term memory tests, a memory search test, a series of numerical additions and an attention demand test. The study showed no differences in performance between groups that could be attributed to the omission of consumption of breakfast.

Critique of the studies

The research studies reviewed in this section are not free of methodological problems. As indicated before, the study in Singapore (Chun 1971) provides insufficient information to discriminate clearly whether the past nutritional history of the students or their current nutritional status adversely affects their school performance. A similar problem exists in the study in the Philippines (Popkin & Lim-Ybanez, 1982). Both studies also fail to provide sufficient information on the socio-economic background of the subjects. There is evidence of a positive relationship between socio-economic status and school achievement even among children raised in rural populations where malnutrition is endemic. Moreover, within these populations there is also a relationship between pre-school measures of intellectual competence and subsequent school achievement and enrolment (Irwin, et al. 1978).

The two studies (Webb & Oski, 1973; 1974) on iron deficiency anemia also face the problems of diagnostic sensitivity and lack of information on the socio-economic background of the students. As already noted, some, if not most, of the children included in these studies were probably not iron deficient anemic as they were labelled. It is possible that the students who were classified as anemic were the most economically deprived students within the classroom, and their poor scholastic

performance was due to their social status and not to their iron status. Finally, the study on hunger (Pollitt, et al. 1983) was conducted in an experimental situation which is substantively different from the context of a classroom; thus, the ecological validity of this study is questionable. The cognitive problems identified among the children in the no-breakfast situation may not manifest themselves in the school. The student may learn how to compensate effectively in the classroom for such cognitive limitation related to the fact that he has not eaten for too many hours.

Conclusion

As indicated above, the studies reviewed are not free of methodological shortcomings. They all have a certain degree of uncertainty; therefore, from each one of them it is legitimate only to draw tentative inferences, rather than conclusive statements. These uncertainties, however, fulfill an important scientific function by raising critical questions about basic issues of human development.

At the same time it must be recognized that most studies reviewed concur in suggesting that the nutritional status of the student is a variable that determines in part educational performance. The undernourished child, the anemic child, or the child who goes to school without eating after an overnight fast, does not maintain a classroom behaviour conducive to optimal learning. This inference, drawn from a number of studies, carries an enormous weight when it is recognized that the nutritional status of millions of students around the world is far from satisfactory.

A critical issue faced by policy-makers concerned with education is the distinction that needs to be drawn between risk assessment and risk management. On the one hand, the scientists have had serious limitations in assessing precisely the level of risk associated with malnutrition. This is not due to scientific negligence, but to the complexity of measuring, in the human context, the effects of a particular variable in a complex ecological setting. In the other hand, this does not negate that the available data already calls for the management of the risk associated with malnutrition. Although we may not be able to establish exact differences, it is already known that the well-nourished child is more competent in the classroom than the undernourished child - and that this difference is cumulative, or tends to increase with time.

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IV. NUTRITION INTERVENTION, SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION

This section focuses on the effects of nutritionally supplementing the diet of the child in early life and during the school age period, on the child's achievement and performance in school. In the previous section it was established that nutritional deficiencies (i.e. iron deficiency anemia) represent educational risk factors, and place in jeopardy the progress of children in school. Accordingly, it is reasonable to assume that targeted nutrition interventions will have preventive or therapeutic effects.

Programatic actions on nutrition supplementation targeted to nutritionally at-risk people, however, must take into account that these, like any other social intervention, do not operate in a vacuum. Target setting and programme implementation does not necessarily mean that the targets of the programme will be reached and the goals will be fulfilled. Generally, there are a number of confounding factors, in and outside the programme, that condition its effectiveness and the degree to which the goals of the intervention are met. For example, school feeding programmes are expected to raise the total food intake of the child supplementing the child's household diet. However, the family may take the child's school intake as savings, and decrease proportionately the child's food intake at home. Thus, after the implementation of the school feeding programme the child's total food intake will be only slightly higher, or perhaps the same, as the child's usual intake before the programme.

Early supplementation

In the mid-sixties at least five ambitions longitudinal experimental studies were set up in different parts of the world (Colombia, Guatamala, Mexico, Taiwan, United States) to assess whether nutrition supplementation to nutritionally at-risk urban and rural populations had an effect on the cognitive development of infants and children. The target samples were pregnant and lactating women, and their offspring. These studies assumed the following: a) that a net increase in the dietary intake of pregnant women has a salutary effect on the intrauterine environment, prevents foetal malnutrition, and is conducive to the normal growth of the central nervous system in the offspring; b) supplementation during lactation increased the volume of maternal milk and/or improved its biochemical profile fostering the growth and development of the infant; c) that direct supplementation to the infant and young child prevented malnutrition and its adverse effects on the brain, accelerated physical growth, and improved resistance to infection.

Many of the assumptions from most of these studies on nutrition supplementation have not been fulfilled (Joos & Pollitt, 1984). There is little evidence that the dietary supplementation had any substantive effects on the cognitive development during the pre-school or school age period. For example, one of these five nutritional supplementation studies (Wilson, 1981) showed that this early intervention was not directly related to the children's school performance. On the other hand, the tallest children, or probably the better nourished in the pre-school period, obtained the highest grades later in school.

One study conducted in Mexico (Chavez & Martinez, 1981) did show, however, striking developmental benefits from a highly targeted nutrition intervention in a rural Mexican population. Supplementation of 20 mothers began in early pregnancy and was continued with their offspring until approximately the third month after birth. Another group of pregnant mothers from the same community who did not receive food supplementation were followed throughout the study. In the first year of schooling the supplemented children scored significantly higher than the unsupplemented ones in all the achievement tests they took. Among the latter group

about 35 per cent of the children failed on the end-of-course exams, while none of the supplemented children failed. There were no between group differences in IQ or in the ability of the children to read and write.

A critical issue in connection with the effects of this nutritional intervention is whether these effects were strictly due to nutrition. There were other intervening variables that had the potential of having an impact on the development of the experimental children confounding the effects of the nutrition intervention. The delivery of the food supplement is likely to have increased the social contacts and interactions of the recipients. Moreover, the supplemented children were a few (not more than twenty) 'selected' children in the village who received a particular treatment not available to everyone. The potential effects of this social aura cannot be dismissed.

Independently from the nature of the intervention, the study in Mexico does show conclusively the developmental importance of early experiences. It depicts a clear picture of the plasticity of the organism in infancy and the pre-school period. The nature of the experiences during these developmental stages shaped the course of their development and formed in part the aptitudes and attitudes relevant to school. As noted above, there were no differences in IQ between groups; yet, the children receiving food supplements were higher achievers as compared to those who did not receive supplementary foods.

Multifocal interventions

The Mexico study (Chavez & Martinez, 1981) raises an important question in connection with the effectiveness of nutrition interventions. Are the effects of nutrition supplementation more clearly apparent when the programme includes other social inputs, such as education? The results from an intervention study in Cali, Colombia are directly relevant to this issue. (McKay & McKay, 1983)

A paper published in 1978 (McKay, et al. 1977) focused on results from the behavioural tests administered in this intervention study. An experiment was conducted which included groups of children enrolled in the intervention programme at different ages, with the first group beginning when they were 42 months old. Entry requirements included the presence of mild to moderate malnutrition at the time the study was initiated. All cases were selected from neighbourhoods in Cali which were noted for their extreme poverty. Thus, it allowed for a study of how the age of enrolment into the programme determined the magnitude of the effects of the treatment. The intervention was based on a day-care centre and included a systematic educational programme for the children plus health care and daily feeding; the programme operated about eight hours a day, five days a week.

There were four different treatment periods, each of a different duration and each beginning at a different period in the development of the children. The first and longest treatment began when the children were about 42 months old; the last and shortest treatment began when the mean age of the respective group was about 74 months. Two other groups were also used for comparison; one from the same low-income group from which the treated samples were selected, and the other from a high socio-economic group in the city of Cali.

Behavioural testing was conducted before and after treatment periods. The tests that were administered measured different aspects of receptive and expressive language, memory, manual dexterity and motor control, concept formation, and logical thinking. However, for comparative purposes an aggregate score from all tests (described as general cognitive ability) was used.

By 87 months of age the children with the longest treatment had the highest test performance among the treated samples. Another important finding is that for all four groups the initial gain in test performance after the initiation of the treatment varied as a function of the age of the children. The younger the child at the beginning of the treatment, the greater the initial benefits. The results from the analysis of the children's school performance indicates that the number of school failures from year to year increased as the duration of time the children participated in the programme decreased. Similarly, the school grades of the children were negatively related to the age at the time of the pre-school programme enrolment. The younger the children entered into the programme (and the longer they stayed), the higher the grades.

It is indeed difficult to separate the contributions that each of the inputs of this programme had on the development of the children. Yet, some inferences relevant to social and educational policy are warranted. Once more there is strong evidence of the plasticity of the organism among young children. The course of their growth and development was heavily determined by the nature of the experiences that the children had.

A second inference is that the age of the child at the time of enrolment and the duration of the programme made a difference in terms of the results. Thus, the youngest children who were exposed to the programme for the longest period of time obtained the highest benefits. A third inference is that the pre-school intervention had significant effects on the performance and behaviour of the children in the school age period. Finally, it should be underscored that this programme was comprised of nutrition, health and education inputs. It obviously had a higher yield than programmes restricted to a single input.

School feeding programmes

Are monofocal interventions, such as school feeding, effective among school age children? Conceivably, as the child grows older and becomes more differentiated, monofocal programmes may be more successful because they can be targeted to basic and specific developmental needs. At issue here, therefore, is what can be expected form school feeding programmes targeted to nutritionally at-risk children.

Evaluations in developing countries of the nutritional and educational benefits of school feeding programmes have been generally unsuccessful (Levinger, 1983). A large number of confounding variables enter into play in evaluations conducted within the school and classroom setting, which work against accurate evaluations. Evaluations of the educational benefits of school feeding programmes in the United States (Pollitt, et al. 1978) have been characterized by an absence of specific hypotheses, ambiguity in the definition of variables, a lack of data on the validity and reliability of the measures used, and a lack of consideration of relevant moderating variables. Pooling the data from different studies, however, led to some tentative inferences. In connection with short-term hunger (e.g. lack of breakfast) the data suggests that this physiological condition has adverse effects on emotional behaviour, arithmetic and reading ability, and physical work output. These findings agree with those from experimental studies on the effects of short-term fasting on problem-solving behaviour. On the other hand, the evaluations of long-term educational benefits of school feeding have, on the average, failed to yield statistically meaningful findings.

One evaluation on the educational benefits of giving a school meal to a class of children that deserves particular attention is a study conducted in Jamaica (Powell, et al. 1983). This study was carried out in a government run comprehensive school, situated in a rural mountainous area in the island. The majority of students came from poor farming families and ranged from 11 to 17 years of age. Giving

breakfast to a class of school children had a significant effect on attendance and arithmetic scores. These findings are particularly meaningful because the evaluation controlled for the socio-psychological variables that generally confound this type of evaluation. The increased attention which children receive in nutritional intervention programmes was ruled out by including a control group which was given a syrup drink.

Critique of the studies

The studies on the effects of early nutrition supplementation on later behavioural development have faced a serious methodological difficulty in measuring the total nutrients intake of the participants. There have been no accurate assessments of the extent to which the nutritional supplement replaced the usual diet of the participants. Thus, the definition of the 'supplement' has been generally imprecise.

In one study (Wilson, 1981) the measurement of the supplement was further complicated by the fact that the food was delivered in a feeding station. Mothers and children who received the supplement had to visit the station to receive the supplement. Thus, there is a risk of a self selection bias, so that the people who received the supplements also had some social and behavioural characteristics which made them different to those who decided not to receive the supplement. In another study, (Chavez et al. 1981 , the intervention probably included a potent social intervention in addition to the nutrition supplementation, although the former was not programmed. The general intervention (social and nutritional) may have activated behaviours in the parents of the experimental children, and in other members of the community, which in turn could have produced the effects attributed solely to the nutrition supplementation.

The Cali study (McKay, et al. 1983) had a complicated research design, which required longitudinal comparisons of different groups of children exposed to the intervention at different developmental periods. Moreover it included education and health services in addition to the nutrition intervention. Accordingly, it has been extremely difficult to separate the effects of the various inputs of the programme. This information would have significant theoretical and practical importance.

Conclusion

Evaluation of school feeding programmes (Powell, et al. 1983; Pollitt, et al. 1978) are obviously complicated by the nature of the intervention itself and its ecological context. Often the nutritional characteristics of the meals provided in school do not meet the nutritional needs of the school children. Moreover, in the school or classroom setting there are a number of variables associated with both the recipients and the institutions which are likely to interact with the nutrition programme and determine its outcome. Reviews of the studies on the educational and cognitive effects of school feeding programmes (Pollitt, et al. 1978; Levinger, 1983) have not been able to demonstrate without any reasonable doubt, that these programmes do indeed benefit the participants. On the other hand, it must be recognized that the lack of evidence may be due to the inherent complexities of the evaluation, and not due to a genuine lack of effects.

The studies in Mexico (Chavez et al. 1981) and Cali, Colombia (McKay et al. 1983) present conclusive evidence that the developmental course of children is shaped by the nature of the developmental experiences they face. Both studies prove that improvements in the quality of living among nutritionally at-risk children is conducive to the acquisition of attitudes and aptitudes which are necessary in the context of the formal educational system. It is apparent, however, that nutrition interventions per se, as monofocal programmes, are not as successful as those multifocal interventions which add educational and health services to a good diet.

Conceivably, more integrative approaches to school feeding where the specific developmental needs are taken into account may lead to a greater success in this type of intervention directed to children.

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V. CONCLUSIONS

Throughout the developing world 'educational wastage' represents one of the largest and most significant educational problems, involving a high human and capital cost. Educational wastage generally refers to the number of children who repeat a grade, or who drop out of school. Repetition is defined as the student who, throughout a given school year, remains in the same class and performs the work of the previous year. Dropping out is defined as the student leaving before the end of the final year of the educational course in which he is enrolled. The greatest problem of 'wastage' is found in Africa, where in some countries 30 per cent or more of their children (boys and girls) in primary education are defined as repeaters. In 1980 among English-speaking countries in Africa, the average level of repetition was around 6.1 per cent; while for French-speaking countries the average was about 22.6 per cent. There are also a large number of South and Central American countries where 15 per cent or more of their primary school students are repeaters (i.e. Honduras, Guatamala, Dominican Republic, Peru, Brazil) (Unesco Division of Statistics in Education, 1984).

The following table presents the coverage and median percentage of repetitions in primary education.

Coverage and median percentage of repetitions in primary education, boys and girls

	Coverage[1] 1980 %	Number of countries	Percentage variation in number of repeaters	Median percentage of repeaters
TOTAL	62.8	121	0.0 - 46.6	10
Africa	60.1	42	0.0 - 46.6	16
Latin America and the Caribbean	89.4	24	3.6 - 25.8	12
Asia and Oceania	46.4	32	0.0 - 17.8	8
Europe and USSR	86.6	23	0.0 - 19	2

1. Representativeness of the countries examined with reference to total enrolments in primary education.

Evidently, the human and capital cost of educational wastage varies according to a number of factors. The educational implications of dropping out are significantly different between those children who learn to read and write before they leave school, from those who are illiterate. Likewise, the occupational future of children who drop out at the beginning or at the end of the primary school period will also be different. In any event, coping with educational wastage requires an in-depth analysis of its roots - of its distal and proximal causal factors - so that relevant policies can remediate it, if not prevent it.

An additional significant problem partly related to educational wasting, is that of children who never enroll in the formal educational system. Either because schooling is not available, or it is too far, or because of economic limitations of the family, or of cultural practices, some children (mostly girls) fail to go to school altogether. Thus, in these cases, a serious obstacle is placed in front of the social and economic development of those children even before they have reached adolescence.

A substantive body of literature has examined the determinants of school performance, with a particular emphasis on school wastage. As indicated before, these determinants vary, and they tend to differ between developed and developing countries. In this latter case, economic factors generally play a salient role. Within this literature there has been a selective omission of nutrition and health as potential determinants of school performance and wastage. This omission is surprising because, in some cases, the limitations imposed by nutritional factors are dramatic, such as in vitamin A deficiency.

This monograph reviewed three main areas of the relationship between nutrition and education: (a) the effects of early undernutrition on subsequent intellectual function and school progress; (b) the relationship between the nutritional status of the student and school progress; (c) the educational consequences of nutrition intervention programmes. Most studies reviewed within each of these categories have serious methodological problems; conclusive inferences on the basis of any one of these studies is therefore unwarranted. However, it is recognized that the studies reviewed generally agree of their findings. This convergence of results depicts a picture that shows nutrition as an important determinant of educational performance, and as a potent resource to decrease 'educational wastage'. The following are conclusions justified by the data currently available.

1. The intellectual function during school age, and the educational progress of children with a history of early, severe and chronic malnutrition born into conditions of severe social and economic deprivation are at high risk. It is to be expected that the children will have low school achievement, will tend to repeat grades, and maintain a high drop-out rate.

2. The contribution to educational wastage by undernourished children will depend on the prevalence of severe malnutrition in the country. This relationship will be maintained unless there are specific compensatory programmes directed to remediate the effects of undernutrition prior to the enrolment of children in school.

3. The highest educational risk is found among those children whose early, severe and chronic undernutrition coexisted with a physical environment conducive to a high incidence of communicable diseases, and a social environment that fails to provide opportunities for learning. The lowest risk is found among children with a similar history but subsequently exposed to a salutary environment that stimulated the child's educational potential and meets basic social-emotional needs. The magnitude of the cognitive deficits likely to follow an early, severe and chronic malnutrition cannot be definitively established. Early and chronic malnutrition is not a sufficient condition for later intellectual deficit. Many intervening variables enter into play (such as the nature of the social environment) to determine the nature of the final developmental and educational outcome.

4. Multifocal intervention programmes that combine nutrition supplementation, health care, and educational stimulation have significant developmental impact. Children with a history of moderate to severe malnutrition exposed to these programmes beginning as late as 42 months of age have had

substantive improvement in cognitive performance. Their school achievement and progress has also been significantly higher than children who were better off nutritionally in early life, but were not exposed to the intervention programme. The earlier the intervention and the longer the duration of multifocal programmes, the greater the developmental and educational benefits accrued. Thus, it is expected that pre-school multifactorial programmes will have a significant effect on the decrease of school wastage among populations where malnutrition is endemic and there is a high incidence of communicable diseases.

5. The remedial or preventive effects of monofocal nutrition supplementation intervention programmes during early life on the intellectual deficits associated with early chronic undernutrition are questionable. Nutrition supplementation targeted to pregnant and lactating women, and to infants and young children have shown no effects on the mental development of children once they reach school age. Accordingly, the contribution that this modality of intervention will make on educational improvement is probably negligible.

6. Iron deficiency anemia among school students represents an impediment to learning. This evidence has educational implications which are dramatic, because of the large number of children likely to be anemic both in developing and developed countries. It has been estimated that there are about 1.3 billion people who are anemic around the world. The effects of iron deficiency on cognitive function are reversible. Iron repletion therapy among iron deficient anemic pre-adolescent children resulted in significant improvements in school achievement measures. The underlying mechanisms whereby iron deficiency affects learning are not known. Impediment in learning does not necessarily mean, however, that higher cognitive processes have been affected. Iron deficiency is likely to affect the level of alertness (arousal) of children, which in turn affect attention and, therefore, learning.

7. Among well-nourished children a nineteen to twenty hour fasting period affects attention, and the capacity to solve problems of visual-perceptual organization. There is also suggestive evidence from evaluations of school feeding programmes in developed countries that not taking breakfast affected performance in reading and arithmetic tests.

8. Children with low calorie intake over long periods of time reach a state of energy balance through reductions in activity level. Activity is a key mechanism whereby children explore, and relate to their social and physical environment. Thus, reductions in activity represents a loss of significant opportunities for learning. There is no information regarding the cognitive effects that may result, among undernourished children, from going to school without having had a meal after an overnight fast. Compensatory mechanisms may protect cognitive function from the adverse effects of low caloric intake during school hours, among children who are used to this type of feeding schedule.

9. There is strong suggestive evidence that school feeding programmes in developing countries result in an increased attendance among recipients. This increase may have significant educational benefits in the long run as it ensures the exposure of the student to the materials taught in school. There is no conclusive information from developing countries that school feeding programmes (breakfast or lunch) has specific educational benefits, such as improvements in achievement measures or higher concentration.

The evidence presented throughout this monograph, and the conclusions that have been advanced indicate that it is imperative to include nutrition as a determinant of school performance and achievement. Early malnutrition and poor nutritional status among students can, and will have significant adverse effects over school progress, and contribute significantly to school wastage. Children whose learning is slow and have difficulties mastering school material are candidates with high chances of repeating grades and dropping out early from school.

Demands for definition of the specific mechanisms through which early severe and chronic malnutrition affects subsequent school performance, or for the definition of the process through which iron deficiency affects attention cannot be presently satisfied. The information is not available, and there is no way at present of assessing accurately the risks involved. However, it is necessary not to equate risk assessment with risk management. The data available is conclusive to demonstrate that the protection of the child's nutritional status during his early formative years and during the school period will result in a better student, and will significantly decrease the human and capital costs of school wastage.

APPENDIX

TABLE 1

EARLY NUTRITIONAL STATUS AND EFFECTS ON
SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION:

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Bartel et al (S. Africa)	31 black children hospitalized for kwashiorkor or marasmic-kwashiorkor with no neurological involvement	<27mo	31 siblings close in age with no history of hospitalization for acute PCM N=31 yardmates similar in age with no history	6-14 yr	-Category test -WISC Maze Test	No significant differences between mean scores of groups compared..
Cravioto et al. (Mexico)	39 children hospitalized for severe malnutrition (kwashiorkor with edema and skin lesions; weight ≥40% below mean expected for age)	4-30 mos.	39 siblings	5-11	-WISC-IQ -Auditory-Visual Integration -Visual-kinetic competence	Siblings scored higher than index children on all tests.
Das & Soysa (Sri-Lanka)	42 hospitalized for marasmus & kwashiorkor. Gomez Grade 3, growth retardation, edema	2.5-4.5 yr.	42 neighborhood children matched on age and sex 33 siblings 33 neighborhood children matched with siblings on age & sex	mean=116 mos mean=120 mos.	Raven's Matrices; Figure Copying; Memory-for Designs, Visual Short-term Memory; Digit Span; Serial Recall; Cross-Modal Coding	No significant differences between index and control children nor between siblings and their controls on any test.
Edwards & Craddock) (Australia)	29 malnourished school children (Head circumference <10th percentile; height or weight below 10th percentile.)	N.A. [1]	29 adequately nourished matched for age, sex & social status	Index: mean=9.3 yr. comparison: mean=9.6 yr.	L.M. Binet IQ Test	Malnourished group had significantly lower mean IQ.

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TABLE 1 (contd.)

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Galler et al. (Barbados)	129 (52♀, 77♂) with moderate or severe marasmus (Grade II or III on Gomez scale - 75% or less of standard weight for age);	< 1 yr	129 children from same school matched for age, sex & other criteria except history of PEM	5-11 yr	Teacher questionnaires to evaluate classroom behavior (attention, social skills, physical appearance, emotional stability, special problems) & attendance.	Mean IQ of index significantly lower than comparison. Differences in attention, social inteaction physical appearance & emotional stability. Differences not explained by SES at the time of the follow-up.
Graham & Adrianzen (Lima, Peru)	110 children hospitalized for marasmus or kwashiorkor	N.A.[1]	188 younger or older siblings with no history of clinical malnutrition 445+ children from private school 232+ children from public school	6-12 yr.	Grade-for-Age	No difference in grade for age of index and siblings; both had lower grade for age than other school children. Failure rates after age 7: 43 & 41%/yr in index and siblings vs. 19 & 25%/yr in the private and public schools.
Hoorweg & Stanfield (Uganda)	20 age 8-15 mos. 20 age 16-21 mos. 20 age 22-27 mos 11 males & 9 females in each group (Clinical energy & protein malnutrition requiring hospitalization)	<28 mos.	20 no history of clinical malnutrition	11-17 yr.	Raven Matrices: Luganda vocabulary; WISC arithmetic test; Short version of Porteus Mazes; Block design; Memory-for-Design (errors); Knox cubes; Rote Learning; Incidental Learning	All 3 groups of index children scored significantly lower on Raven Matrices, block design, memory-for-design & incidental learning. No relation between age at hospitalization and scores. Severity of acute changes at admission not related to scores. Negative relation between scores & degree of chronic undernutrition significant for Matrices, arithmetic, block design, Memory-for-Designs and Knox Cubes.

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TABLE 1 (contd.)

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Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Nwuga (Nigeria)	52(29)♀ & 23 ♂) Severe kwashiorkor (serum albumin ≤2 mg/ 100 liters)	1-3 yr	Group 1: 34 siblings, not matched for sex, within ? years of age of index. Group 2: 32 classmates matched for neighborhood age, sex, family size, birthorder, religion & SES Group 3: 38 upper class children matched as for group 2 save for SES Group 4: 9 ex-kwashiorkoriases with same characteristic as index cases except for rural address.	Index: Mean 9.8±.06 years Group 1: Mean 10.35±.5 Group 2: Mean 9.84±.09 Group 3: Mean 9.66±.07 Group 4: Mean 9.94±.19	Wechsler Intelligence Scale for Children; Wechsler Pre-School & & Primary Scale of Intelligence; & Raven's Scale.	Index had lower scores than any of the comparison groups except rural ex-kwashiorkor cases; Selective negative long-term effect on higher cognitive skills; no differences in color-shape & shape discrimination & animal house tests; Test scores & age at hospitalization, were independent of each other.
Richardson (Jamaica)	74 boys treated for severe malnutrition (marasmus, kwashiorkor and marasmic-kwashiorkor) who received an average of 8 weeks inpatient care	<2 yr.	74 classmates or neighbors of same sex and similar age with no history of hospitalization for malnutrition. Also siblings without history of malnutrition.	Index and Comparison 6-10 yrs. Siblings: 6-12 yrs.	WISC IQ Teacher Questionnaire; Classwork; Social relationships; Conduct Problems; Peer Choices Wide Range Achievement Test of reading, spelling, and arithmetic (WRAT)	Index cases and boys who were short had significantly lower IQ's than their comparisons; however, effect of nutritional history strongly influenced by social background Index children rated significantly lower than their comparisons in 9 of 11 classroom behaviors; Index children more isolated & withdrawn, less liked by peers, & had more conduct problems. No differences

TABLE 1 (contd.)

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Richardson (contd.)					Teacher assessement of overall school work, special problems with school work. Median school grades on each subject taught (very good to poor).	found between siblings and comparisons Index had lower scores on all three tests of the WRAT than their comparisons; scores of Index & siblings did not differ. Index children had lower rating of overall school work than comparisons, had more special problems and lower median grades on subjects taught. No differences between siblings and comparisons. No relation between any measure and age at hospitalization
Singh et al (India)	204 male children randomly selected from corporation schools & a public school. Divided using Gomez Classification 78 Subclinical (75-90% of expected wt/age) 69 Grade I (61-74% of expected wt/age) 19 Grade II (51-60% of expected wt/age)	NA[1]	N=38 children ≥91% of expected weight for age	5-9 yrs	Teachers grading based on day-to-day assessment Final exam marks	Groups were comparable for age but not for social class. Teachers rating of day to day performance increased significantly with nutritional status Exam marks increased significantly with higher social class. Within each social class malnourished children had significantly lower exam marks than better nourished children
Stoch & Smythe (South Africa)	20 (9♂, 11♀) "grossly undernourished" based on weight (mean weight below the 2.5 centile)	10 mo to 3 yr	20 matched for age and sex selected from nursery school; controls had much better living conditions	15 years after study initiated (13.7 - 18.2 yrs) mean=16 yrs	General intelligence: New South African Individual Scale (NSAIS); Bender Visual-Motor Gestalt Test (BG); Human Figure Drawing (HFD); Columbus projective test of social integration	Index children had significantly lower scores on all measures.

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TABLE 1 (contd.)

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Winick et al. (Korean in U.S.)	42 malnourished (below 3rd percentile for height and weight) 52 moderately nourished (3rd to 24th percentile for both height & weight). All were females who were full-term at birth.	<2yr when admitted to adoption agency <3yr when adopted	47 well-nourished (≥25th percentile for height & weight)	Grade 1-8	Standardized IQ and achievement tests obtained from schools (converted to stanine scores)	Malnourished children scored lower than well-nourished group on IQ tests and scored lower than both moderately and well-nourished groups in achievement tests. However, all groups had surpassed American norms.
Nguyen et al.	57 malnourished 109 moderately nourished	2-5yr old when admitted to adoption agency;	74 well nourished	"School-age"	Standardized IQ & Achievement Tests obtained from schools (converted to Stanine scores)	Malnourished group scored lower than well-nourished on IQ tests and scored lower than both moderately & well-nourished group on achievement. Differences in achievement significant only for those admitted to agency at ≤3 years. Children adopted before age 4 did better than those adopted after age 4, independent of nutritonal status. Children severely malnourished before adoption did not reach the American average and scored significantly lower than the other two groups.

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TABLE 2

CURRENT NUTRITIONAL STATUS AND EFFECTS ON SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Chun et al. (Singapor)	113 male students below 10th percentile for height & weight	N.A. [1]	936 between 10th & 90th percentile for height & weight 74 above 90th percentile for height & weight	12 yr.	Failure rates on Primary IV exams	Failure rates inversely related to weight and height percentile categories & significantly different in all groups.
Pollitt et al 1983 (U.S.)	32 in Study I 39 in Study II		Each subject was own control (tested in fasting & non-fasting state).	9-11 yr	IQ: Peabody Picture Vocabulary Test (Study I)	More errors on hard & easy MFF tasks in fasting condition but significantly different only for hard tasks.
					Slosson Intelligence Scale (Study II)	Fasting insulin & glucose values were negatively correlated with number of errors and hard tasks.
					Matching Familiar Figure (MFF) test (Study I & II)	No effect of fasting on the central component of the HCI test
					Hagen Central Incidental (HCI) test (Study I & II)	Scores on the incidental component were higher in the fasting condition and were negatively correlated with insulin levels
					Short-term memory (Study II)	
Popkin & Lim-Ybanez (Philippines)	240 (40 children from each of 3 rural & 3 urban schools) Nutritional status assessed by Hemoglobin, % wt/ht, presence of NUTRIBUN supplementation program in school & child report of average hunger status	N.A. [1]	N.A. [1]	12-14 yr	Survey of Outcome of Elementary Education (SOUTELE) achievement tests: Ability to concentrate; Participation in extracurricular activities; Absenteeism	Hemoglobin significantly related to language learning & composite score and to less absenteeism; % wt/ht significantly related to mathematics learning & ability to concentrate; Nutribun program related to less tion program in school, absenteeism; Being hungry lowered language & composite scores.

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TABLE 2 (contd.)

Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Webb & Oski 1973 (U.S.)	92 Anemic male with Hg 10.1 to 11.4 gm/100 ml	NA [1]	101 normal students with Hg 14.0 to 14.9 gm/100 ml	12-14 yr	Iowa Tests of Basic Skills (Levels A-F/ Form 3) Composite Score	Anemic students had significantly lower composite test scores.
Webb & Oski 1974 (U.S.)	74 Anemic male students with Hg values of 10.1 to 11.4 gm/100 ml	NA [1]	36 normal students with Hg values of 14.0 to 14.9 gm/100 ml	13-14 yr	Behavior Problem Checklist ratings by teachers (conduct problems, personality disturbances, inadequacy-immaturity).	Anemic students had more severe conduct disturbances; no differences between anemics & non-anemics in personality disturbance or immaturity.

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TABLE 3

NUTRITION INTERVENTION AND EFFECTS ON SCHOOL ACHIEVEMENT AND INTELLECTUAL FUNCTION

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Author and Place of Study	Experimental Subjects: Number and Description of Nutritional Condition	Experimental Subjects: Age at Time of Hospital Admission	Number and Description of Comparison Subjects	Age of Experimental and Comparison Subjects at Evaluation	Tests Used and Type of Measure Obtained	Results
Chavez & Martinez (Mexico)	17 non-supplemented ("Malnourished")	N.A.[1]	17 supplemented ("well nourished")	1st grade	Grade on final exams; National exams; Detroit-Engel test; ABC test; Reading & writing tests; School behavior Terman-Merrill	Supplemented group scored significantly higher on all tests except reading and writing. No differences in Terman-Merrill IQ Supplemented children more active attentive, participate more. Non-supplemented spend more time sleeping & crying. Improvement from beginning to end of school year much greater in supplemented group.
McKay & McKay (Columbia)	248 low SES and children with subnormal	N.A.[1]	30 high SES children, no treatment N=72 low	8-10 yrs	Stanford-Binet IQ at 8	IQ at 8 years was higher in the treated groups and the program of longest duration had the greatest effect. School failures decreased with greater amount and duration of intervention.
Pollitt et al (U.S.)	not summarized					
Powell et al (Jamaica)	44 experimental students who received	N.A.[1]	38 control 33 placebo	Mean ages: Exp. = 12.6 yrs Control = 12.5 yrs Placebo = 12.6 yrs	·School achievement (Wide Range Achievement Test) ·Attendance	Giving breakfast had a significant effect on arithmetic scores and attendance. Breakfast had no effect on reading or spelling.
Wilson (Guatemala)	100 students who completed ≥ 1 yr. school with differings levels of supplement & home diet intake (total caloric intake age 72 to 84 months).	N.A.[1]	N.A.[1]	about 99 mo. (8yrs.)	Verbal attainment (naming and recognition tests); Mathematics & language grades; Teacher assessment of performance at ~99 mo.	Teacher assessment strongly related to total caloric intake

1. Not available

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